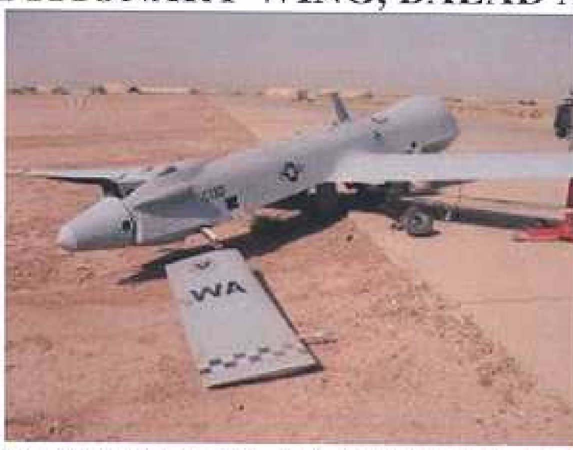
UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

MQ-1B, T/N 04-003133

46th EXPEDITIONARY RECONNAISSANCE SQUADRON
332d AIR EXPEDITIONARY WING, BALAD AIR BASE, IRAQ



LOCATION: BALAD AIR BASE, IRAQ

DATE OF ACCIDENT: 30 JULY 2007

BOARD PRESIDENT: LIEUTENANT COLONEL TODD J. FLESCH

Investigation conducted pursuant to

Air Force Instruction 51-503

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR COMBAT COMMAND
LANGLEY AIR FORCE BASE, VIRGINIA

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20 MAR 2008

MEMORANDUM FOR ACC/JA

SUBJECT: Accident Investigation Report: MQ-1B, S/N 04-3133, 332d Air Expeditionary Wing, Balad AB, Iraq, 30 July 2007

I have reviewed the Accident Investigation Board Report regarding the MQ-1B, S/N 04-3133, that impacted the ground short of runway 32 on final approach to Balad Air Base, Iraq on 30 July 2007. The report prepared by Lieutenant Colonel Todd J. Flesch complies with the requirements of AFI 51-503 and is approved.

R Michael Worden
R. MICHAEL WORDEN
Major General, USAF
Vice Commander

Attachment:
Accident Investigation Board Report

EXECUTIVE SUMMARY

AIRCRAFT ACCIDENT INVESTIGATION

MQ-1B, T/N 04-003133
BALAD AIR BASE, IRAQ
30 JULY 2007

On 30 July 2007, at 2300 local/1900 Zulu (Z, or Greenwich Mean Time), an MQ-1B Predator, a remotely piloted aircraft, tail number 04-003133, impacted the ground short of runway 32 on final approach to Balad Air Base (AB), Iraq. The Mishap Aircraft (MA) was forward deployed to Balad AB from the 432d Wing, Creech Air Force Base, Nevada, in support of Operation IRAQI FREEDOM. The Mishap Crew (MC) was assigned to the 46th Expeditionary Reconnaissance Squadron as part of the launch and recovery element. Damage to the MA and runway lighting totaled approximately $2.21M. There were no deaths or injuries associated with this mishap.

The MC, consisting of the Mishap Pilot (MP) and Mishap Sensor Operator, assumed control of the MA for the final 18 minutes of the 20.4 hour sortie. The MC was current and qualified to conduct the mission.

Nine minutes after assuming control, the MC detected engine overheat indications, including fluctuating exhaust gas temperature readings in two of the MA's four cylinders. The MC declared an In-flight Emergency for "Engine Overheat" 15 miles from Balad AB. The MP was issued immediate clearance inbound. During the final 11 minutes of flight, the MA experienced abnormal engine operations that resulted in power losses. The MC applied "Engine Overheat" checklist items and were initially able to maintain glidepath and appropriate airspeed parameters. Approximately one mile from the runway threshold, the MA engine lost power in two cylinders. Approximately 17 seconds later, the final two cylinders lost power, resulting in engine failure. A failing, and ultimately failed, ignition system caused the engine-out condition. This engine failure occurred on short final, a critical phase of flight, and left the aircraft without sufficient energy to glide to the airfield. The loss of power induced a stall and an irrecoverable loss of airspeed. The MA impacted 92 meters short of the runway on the unprepared under-run surface.

The Accident Investigation Board President determined, by clear and convincing evidence, the primary cause of this mishap was the result of a failed Ignition Module (IM). The IM is comprised of two redundant Capacitive Discharge Ignition (CDI) circuits. The first CDI failed due to an improperly manufactured wire-to-wire connection that was not soldered as required. This failure increased the electrical load on the remaining CDI while reducing the IM to a single point of failure. The second CDI failed due to low reliability at higher than normal operating temperatures caused by higher engine settings, increased electrical load, and an IM enclosure design that could not adequately dissipate the resulting heat.

STATEMENT OF OPINION

MQ-1B, T/N 04-003133 ACCIDENT
30 JULY 2007

Under 10 U.S.C. 2254(d), any opinion of the accident investigators as to the cause of, or the factors contributing to, the accident set forth in the accident investigation report may not be considered as evidence in any civil or criminal proceeding arising from the accident, nor may such information be considered an admission of liability of the United States or by any person referred to in those conclusions or statements.

PRIMARY CAUSE

I find by clear and convincing evidence that the primary cause of this mishap was the dual failure of the redundant engine ignition system.

Firstly, an improperly manufactured wire-to-wire cable (W452) from the engine's magneto to the Ignition Module (IM) shut off power source to the lower spark plugs in the Mishap Aircraft's (MA) cylinders. It was undetermined during this investigation when this initially occurred but is suspected to have occurred after the pre-flight ignition coil drop test. The effective loss of this ignition source reduced the dual redundancy ignition system to one Capacitive Discharge Ignition (CDI) single point of failure. As a result, the second CDI overheated internally and ultimately failed because of higher electrical loads and subsequent higher internal temperatures.

Secondly, the remaining CDI circuit failed due to low reliability at high operating temperatures due to an improperly designed IM enclosure. The IM enclosure did not allow adequate cooling to the remaining CDI. This CDI failed at the time of aircraft indications and pilot awareness of high Exhaust Gas Temperature (EGT) values and splits among the MA's individual cylinder EGT readings. The EGT split in the MA during the final 11 minutes were not indications of hot combustion but rather an indication of negative combustion. When unburned (negative cylinder combustion) fuel was introduced into the exhaust manifold it came into contact with the hot exhaust pipe. The unburned fuel ignited and burned within the exhaust pipe and registered through the EGT sensors as high temperature indications. The only way for the pilot and sensor operator to ascertain the difference between normal EGT indications (with normal cylinder combustion) and high or low EGT indications (due to weak or random ignition), is through monitoring EGT split. The indication of cylinder EGT splits during this mishap was indicative of a failed IM producing random ignition source.

The second failure was not immediate. At first, the magneto began to fire randomly on one coil that controlled cylinders 1 and 2 while the magneto appeared to operate normally on the other coil that controlled cylinders 3 and 4. The random ignition condition initially manifested itself in cylinders 1 and 2 during the final 11 minutes of flight causing lower overall power output of the aircraft engine. To compensate, the Mishap

Pilot (MP) increased throttle inputs to maintain his approach airspeed and descent rate. The remaining ignition circuit began to overheat when stressed with increased electrical loading at higher power settings resulting in random fire, fail, and recovery sequence of ignition source to the engine. Post mishap analysis on the Mishap Engine's (ME) IM confirmed that when CDI boxes fail under increasing internal temperatures, they fail one-half of the cylinders and the remainder some time later. Aircraft data log graphs show the aft cylinders (1 and 2) failed 57 seconds prior to impact. As the MP increased power to compensate for the loss of engine power the remaining ignition circuitry failed in the forward cylinders (3 and 4) resulting in a complete engine out condition 17 seconds later. This type of ignition failure is typical of an overheated IM. The IM overheat was caused by an increased load from the first failure and an inadequate IM enclosure design that prevented proper cooling/ventilation to the remaining internal CDI circuit.

At the time of impact, the ME recovered all, or partial, operation. Data-link to the MA was lost upon impact. The sudden restart of the ME was likely the result of the secondary CDI coming back online after the improperly manufactured (wire-to-wire) electrical connection of the redundant IM shifted in position and re-established contact.

30 January 2008

TODD J. FLESCH, Lt Col, USAF
President, Accident Investigation Board

SUMMARY OF FACTS AND STATEMENT OF OPINION
MQ-1B, T/N 04-003133, 30 JULY 2007
BALAD AB

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COMMONLY USED ACRONYMS AND ABBREVIATIONS

§	Section
°	Degree(s)
AB	Air Base
AEW	Air Expeditionary Wing
AFB	Air Force Base
AFI	Air Force Instruction
AFTO	Air Force Technical Order
AGL	Above Ground Level
AIB	Aircraft Investigation Board
ATC	Air Traffic Control
ATO	Air Tasking Order
BPO/PR	Basic Postflight/Preflight Inspection
BFS	Battlespace Flight Services
C	Celsius
CAMS	Core Automated Maintenance System
CAOC	Combined Air and Space Operations Center
CAPs	Critical Action Procedures
CDI	Capacitive Discharge Ignition
CHT	Cylinder Head Temperatures
Dash-1	AFTO 1Q-1(M)B-1 Flight Manual
EGT	Exhaust Gas Temperature
ERS	Expeditionary Reconnaissance Squadron
F	Fahrenheit
GCS	Ground Control Station
GDT	Ground Data Terminal
GLS	GPS Landing System
GPS	Global Positioning System
IFE	In-flight Emergency
IM	Ignition Module
inHg	Inches Mercury
IOS	Interim Operational Supplement
IP	Instructor Pilot
IR	Infrared
LLC	Limited Liability Company
LRE	Launch and Recovery Element
Lt Col	Lieutenant Colonel
M	Million
MA	Mishap Aircraft
MAP	Manifold Air Pressure
MC	Mishap Crew
MCE	Mission Control Element
ME	Mishap Engine
mIRC	Microsoft Internet Relay Chat
MP	Mishap Pilot
MSL	Mean Sea Level
MSO	Mishap Sensor Operator
MTS	Multi-Spectral Targeting System
NOTAMS	Notice to Airmen
ORM	Operational Risk Management
PCM	Primary Control Module
PRD	Pilot Reported Discrepancies
psi	Pounds per Square Inch
RPA	Remotely Piloted Aircraft
RPM	Revolutions Per Minute
RSO	Remote Split Operations
SAR	Search and Rescue
SCM	Secondary Control Module
S/N	Serial Number
TAP	Throttle Actuator Position
TCTO	Time Compliance Technical Order
T/N	Tail Number
T.O.	Technical Order
TOLD	Take-Off and Landing Data
TSgt	Technical Sergeant
USAF	United States Air Force
U.S.C.	United States Code
VIT	Variable Information Tables
Z	Zulu, or Greenwich Mean Time

The above list was compiled from the Summary of Facts, the Statement of Opinion, the Index of Tabs, and Witness Testimony (Tab V).

SUMMARY OF FACTS

1. AUTHORITY, PURPOSE, AND CIRCUMSTANCES

a. Authority

On 19 December 2007, Major General David E. Clary, Vice Commander, Air Combat Command, appointed Lieutenant Colonel (Lt Col) Todd J. Flesch president of an Accident Investigation Board (AIB) to investigate the 30 July 2007 crash of an MQ-1B Predator Remotely Piloted Aircraft (RPA), Tail Number (T/N) 04-003133, at Balad Air Base (AB), Iraq. The investigation was conducted at Nellis Air Force Base (AFB), Nevada, from 15 January through 30 January 2008, pursuant to Air Force Instruction (AFI) 51-503, *Aerospace Accident Investigations*. Technical advisors appointed to the board were Lt Col Sam Morgan (Pilot), Captain Kathy Malowney (Legal), Technical Sergeant (TSgt) Alfredo Gaytan (Maintenance) and TSgt Andrea M. Freeland (Recorder) (Tab Y-3 thru Y-6).

b. Purpose

The purpose of this investigation was to provide a publicly releasable report of the facts and circumstances surrounding the accident, to include a statement of opinion on the cause or causes of the accident; to gather and preserve evidence for claims, litigation, disciplinary, and administrative actions; and for other purposes. This report is available for public dissemination under the Freedom of Information Act (5 United States Code (U.S.C.) § 552) and AFI 37-131, *Freedom of Information Act Program*. This investigation was separate and apart from the safety investigation, which was conducted pursuant to AFI 91-204, *Safety Investigations and Reports*, for the purpose of mishap prevention.

c. Circumstances

The AIB was convened to investigate a Class A mishap involving a MQ-1B Predator RPA, T/N 04-003133, assigned to the 332d Air Expeditionary Wing (332 AEW) and operated by the 46th Expeditionary Reconnaissance Squadron (46 ERS), Balad AB after returning from an armed reconnaissance mission in support of Operation IRAQI FREEDOM on 30 July 2007 (Tab Y-3 thru Y-6).

2. ACCIDENT SUMMARY

On 30 July 2007, at 2300 local time/1900 Zulu (Z, or Greenwich Mean Time), an MQ-1B Predator RPA, assigned to the 332 AEW and operated by the 46 ERS, impacted the ground 92 meters short of runway 32, Balad AB on the unprepared under-run surface. The MA skidded on its fuselage and left wing tip in a counter clockwise direction for approximately 500° (Tab S-3). The initial hard impact damaged the MA's landing gear (which ultimately collapsed), the fuselage, and the Multi-Spectral Targeting System

(MTS). Damage to the MA, T/N 04-003133, totaled $2,209,504. Additional airfield damage consisted of two airfield lights totaling $187. The MA fuselage is repairable but requires extensive refurbishing along with a new MTS unit. There were no ground injuries or damage to private property (Tab P-3 thru P-5).

3. BACKGROUND

The MA was an asset of the 432d Wing, Creech AFB, Nevada, and was forward deployed to Balad AB, approximately 42 miles north of Baghdad, and assigned to the 332 AEW. Taskings for the 332 AEW are provided by the Combined Air and Space Operations Center (CAOC) in support of Operation IRAQI FREEDOM. A Launch and Recovery Element (LRE) crew from the 46 ERS launched the MA from Balad AB. Control was then transferred to the Mission Control Element (MCE) to perform their Air Tasking Order (ATO) tasking. Following completion of assigned missions, the MCE transferred control back to the LRE for recovery operations into Balad AB.

The 432d Wing stood up on 1 May 2007. It has six operational squadrons, one maintenance squadron, with Predators and Reapers. The 332 AEW is host to a C-130 squadron that provides intra- and inter-theater airlift, delivering passengers and cargo to bases around the country. The wing also operates a contingent of HH-60 helicopters that provides combat search and rescue capability for the entire Iraqi theater. The 46 ERS's mission is to provide real time aerial reconnaissance to deployed theater commanders.

4. SEQUENCE OF EVENTS

a. Mission

The mission was a recovery flight returning from a routine armed reconnaissance mission in west central Iraq supporting Operation IRAQI FREEDOM tasked by the CAOC. The Mishap Pilot (MP) and Mishap Sensor Operator (MSO) were assigned to the 46 ERS LRE. Primary duties of the LRE include the performance of takeoff and landing operations, laser boresight, and AB defense. Predator operations are unique in mission execution with the capability to perform Remote Split Operations (RSO). It is common for multiple crews to pilot/operate the RPA on a global scale from stateside and in-country Ground Control Stations (GCS). The MA's mission profile consisted of a crew from the LRE launching the aircraft, several crews from the MCE performing the ATO-assigned mission, and the Mishap Crew (MC) performing the landing. The MC assumed control approximately 20 miles from Balad AB for the final 18 minutes of the 20.4 hour sortie. Handback operations were uneventful and previous crews cited no abnormalities with the MA (Tabs K-3 thru K-4, V-1.6, V-2.3). Handback operations are defined as the transfer of aircraft control from MCE GCS stateside (Satellite) to LRE GCS at Balad AB (Line-of-sight).

b. Planning

Mission planning consisted of a classified daily intelligence briefing, weather briefing, and description of the specific base defense activities and airspace constraints associated with this mission. In the flight briefing, the MC discussed their roles and responsibilities for the recovery and landing back to Balad AB. Specific attention was given to both the aircraft landing data and to the transfer of aircraft control back to the LRE GCS and the MC. The MC performed proper handoff operations in accordance with checklists (Tabs V-1.2 thru V-1.4, V-2.2). The MP was a qualified instructor, fully trained in launch/recovery operations, and had been in theater for two months prior to the mishap. The MSO was qualified in his duties and was also in theater for two months prior to the mishap.

c. Preflight

MA preflight and takeoff was accomplished by a separate LRE crew at 2235Z, 29 July 2007, from Balad AB with no reported discrepancies (Tabs K-3 thru K-4, V-1.6, V-2.3).

d. Summary of Accident

The MC was performing recovery operations of MA back to Balad AB following completion of its mission and uneventful handback operations. Approximately 15 miles from the field, the MC noticed higher than normal EGT readings and a split of EGT indications in two of the MA's four cylinders. The high EGT readings and temperature splits between the MA cylinders is not a normal indication and began at 1849Z. The MC accomplished Critical Actions Procedures (CAPS) in accordance with MQ-1B emergency action procedures. The faulty EGT indications of the MA remained for the final 11 minutes through MA impact short of the runway.

During the final 11 minutes of flight, the MA's engine experienced power losses due to an improperly working aircraft Ignition Module (IM). The IM is the source of engine spark to control internal cylinder combustion that produces engine power output and is a dual redundant system containing two independent ignition circuits or CDIs. An improperly manufactured wire-to-wire connection reduced the IM to a single operating CDI. The remaining CDI within the IM was now the only source of engine ignition. This remaining CDI failed over time when the internal heat capacity exceeded system design capability.

The failure of the IM was not immediate. At 1849Z, engine spark became intermittent producing a random fire and failure spark to cylinders 1 and 2. The split EGT readings between the MA's cylinders were the only indications of cylinder misfires. Initially, only the aft cylinders (1 and 2) were affected. Because of the random and failed spark from the MA's IM, these cylinders were not providing consistent power during the MA's final approach into Balad AB. The MC commanded higher throttle settings to offset the loss of engine power from the failing cylinders. The increased power settings resulted in increased load on the ignition system that increased internal ignition energy and heat load. Per the manufacturer, ignition electronics should not be exposed to temperatures in excess of 80 degrees Celsius (C) (Tab EE-11 thru EE-12). Stressed with increased temperatures over longer periods of time and under increased throttle settings, the IM failed to provide ignition spark to the aft cylinders (1 and 2) at 1859:23Z. This caused the corresponding loss of power to the engine from these cylinders (Tab CC-3 thru CC-7).

Powering the engine after the loss of cylinders 1 and 2 were forward cylinders (3 and 4) (Tabs EE-4, EE-12). The MC responded normally to the sudden drop of power and further increased throttle to the engine. The increased throttle again induced electrical energy into the IM and the remaining CDI circuit that quickly reached capacity and failed. Ignition source to the MA's engine failed completely at 1859:40Z (Tabs CC-3 thru CC-7, EE-10). This MA appeared to impact at 1900:16Z.

The in-flight engine failure was a result of a dual failure of the redundant engine ignition system. The first failure was the improperly manufactured wire-to-wire connection that shutoff power to one of two internal ignition circuits or CDIs. The second CDI failed due to internal heat buildup that produced a random/intermittent and ultimately failed ignition spark to the engines aircraft cylinders (Tabs EE-4, EE-12).

The following is a detailed technical discussion of factual events recovered from engine data log graphs and interviews:

The MC assumed control of the MA for the final 18 minutes of the 20.4 hour sortie at 1842Z (Tab K-3 thru K-4). No discrepancies were noted during the previous 20.1 hour sortie by any of the previous crews prior to handback operations. The MC performed handback duties in accordance with checklist directions and assumed control of the MA uneventfully. The aircraft location was approximately 20 miles south of Balad AB, at an altitude of 8,000 feet above Mean Sea Level (MSL). Observed weather during the mission was few clouds at 15,000 feet and unrestricted visibility with surface winds from the northwest at 6 knots. The surface temperature was approximately 34° C (Tab F-3). After completion of handback operations to the LRE's GCS, the MC began immediate crew coordination for recovery to runway 32 (Tabs V-1.4, V-1.9, V-1.11).

At 1837Z, the MP requested arrival instructions from Air Traffic Control (ATC). The MP was instructed to hold outside of active airspace for approximately a 10-15 minute delay. The MP followed ATC instructions to descend to 4,000 feet MSL, then proceeded inbound on a heading of 320° to avoid active airspace. All MA systems indicated normal, and the MC began preparations for final approach into Balad AB (Tabs N-4 thru N-5, V-1.6).

At 1849Z, the MSO recognized "Engine Overheat" indications, including high Exhaust Gas Temperature (EGT) readings, through red warning indicators displayed on the GCS's Variable Information Tables (VIT). VITs are computer screens contained within the GCS that the pilot and sensor operator can independently monitor to display aircraft performance indicators and system operations, including caution and warning indications. The MP verified the overheat indication, relayed to ATC they were declaring an In-flight

Emergency (IFE), and requested immediate priority for clearance to land. The MA position relative to the landing runway at this time was approximately 12 miles south of the field at 4,000 feet MSL. ATC personnel issued immediate clearance inbound and instructed the MC they were landing on runway 32 (Tabs N-4 thru N-5, V-1.7, V-2.3). The MP instructed the MSO to begin a challenge and response sequence from the emergency procedures "Engine Overheat" checklist (Tab BB-13). These procedures provide the greatest chance of a safe recovery during an engine overheat condition:

Step 1. THROTTLE – AS REQUIRED to attain/maintain safe altitude.

Step 2. ENGINE COOLING FAN – MANUAL AND ON. The MC disregarded Step 2 as EGT overheat indications are not affected by Cooling Fan operations as noted in the MQ-1B operating manual.

Step 3. ELECTRICAL LOAD – REDUCE, and alerts the pilot to ensure the cooling fan is off to reduce electrical loading.

Step 4. AIRCRAFT – LAND AS SOON AS POSSIBLE.

The MP disconnected the MA autopilot function and set immediate course for runway 32, placing the MA flight path marker to the landing runway (Tabs V-1.7 thru V-1.8, V-2.3 thru V-2.4). The MP then verified his descent gradient (700-800 feet per minute) with an approximate 2.5° glideslope. The MA was aligned with the landing runway, holding 75 knots of airspeed and established on a proper glideslope for touchdown on the landing runway with current engine power. The MA was approximately 12 miles from the runway at 4,000 feet MSL which was outside of engine out glide back range of 9 miles under the conditions present. The MA continued the approach, suffering erratic EGT problems, the loss of cylinders 1 and 2 at approximately 0.5 miles, and complete engine loss on short-final.

The following technical information and sequence of events from the engine overheat to the impact is based on information collected by the classified GCS video recorder:

At 1849:39Z, EGT readings began to split amongst the engine's independent four cylinders. EGTs in the aft two cylinders (Cylinders 1 and 2) began registering erratic high temperature readings of 1,650° Fahrenheit (F) compared with the forward cylinders (Cylinders 3 and 4) that indicated 1,300° F. The temperature split between the aft cylinders (High) and the forward cylinders (Normal) is not a normal indication. All other indications remained normal (fuel pressure remained steady at 57.3 pounds per square inch (psi) and engine alternators were 28 volts power at 21 amps each). Engine manifold pressure was stable at 10 inches Mercury (inHg), engine Revolutions Per Minute (RPM) read 3,650, and propeller pitch decreased from 16° to 14°. Oil, water temperature, and pressure readings remained normal (Tab CC-3 thru CC-7). The MP engaged the autopilot airspeed hold function to 75 knots, set the MA flight path marker on the end of runway 32, and used throttle position to maintain airspeed and descent. The MP then verified his descent rate of 800 feet per minute at a glide angle of 2.3° nose low (Tab V-

1.7 thru V-1.9). This technique is common among MQ-1B pilots and is a technique taught during the formal training course for new Predator pilots (Tab V-1.4 thru V-1.5). GCS VIT displays continued to indicate a growing EGT split between the MA's forward and aft cylinders displayed to the MC via red "Engine Overheat" indicators.

At 1850:33Z, the EGT split increased to 300° F between the two aft (High) and the two forward (Normal) cylinders. EGT readings from the aft cylinders (1 and 2) indicated high temperature readings at 1,750° F. EGT readings from the forward cylinders (3 and 4) showed no fluctuations with normal temperature readings at 1,350° F. The fuel injector banks and fuel pressures remained steady and normal. Alternator power, oil, and coolant temperatures remained normal (Tab CC-3 thru CC-7). The MA continued to descend at a rate of 800 feet per minute on a 2.5° glideslope with the aircraft holding at 75 knots. The MC confirmed via a challenge and response the completion of the "ENGINE OVERHEAT" checklist (Tabs V-1.6 thru V-1.7, V-2.4).

At 1851:22Z, the MP reduced throttles down to 2% to adjust the MA's descent rate. The Manifold Air Pressure (MAP) fell to 8.2 inHg. The EGT split rose to 400° F with a peak temperature of 1,804° F in cylinder 2. The rises in the aft EGTs, and the split temperature readings between the forward and aft EGTs, are not normal indications with a reduction in throttle. The injector bank, fuel pressure and power supply remained normal and within limits. Coolant and oil temperatures also remained within limits. Engine RPM was stable at 3,800 then dropped suddenly to 3,400 RPM with no throttle input. The MA was on a consistent glide/flight profile for the intended runway (Tab CC-3 thru CC-7).

At 1851:29Z, the MP quickly throttled the engine up to 20% to account for the loss in RPM. The engine responded with increased power and RPMs stabilized back to 3,800. The MAP rose to 17.4 inHg. At this time, the EGTs for all four of the MA cylinders dropped to normal operating ranges. All engine and ignition operations regained full operation within normal operating ranges. With current engine power, the MA could make the runway with a normal landing. Flight parameters remained consistent with an 800 feet per minute descent rate, and a 2.5° glidepath at 75 knots. The MP continued with the current approach in accordance with checklist procedures (Tabs CC-3 thru CC-7, V-1.8).

At 1851:50Z, 21 seconds later, the EGT split increased to 37° F between the aft cylinders (High) and the forward cylinders (Normal). Cylinder 1 temperature indicated 1,818° F and cylinder 2 temperature indicated 1,858° F. There was no significant change in the MP throttle inputs. The injector bank and fuel pressure behaved normally. MAP was 18.4 inHg, engine speed was 3,405 RPM, Throttle Actuator Position (TAP) was 7.5%, and propeller pitch was 16°. The EGT split of 375° F remained constant for the next two minutes without any appreciable changes in the MP inputs (Tab CC-3 thru CC-7).

At 1853:38Z, the pilot reduced power to idle to increase the MA descent rate. The EGT split remained with cylinder 2 at a peak temperature of 1,844° F. The injector bank and fuel pressure behaved normally. MAP was 9.2 inHg, engine speed was 3,126 RPM, TAP was 0.4% and propeller pitch was 8° (Tab CC-3 thru CC-7). The MP instructed the MSO to begin verbalizing the "Engine Failure" Checklist in the event of a complete loss of all engine power:

Step 1. GLIDE-ESTABLISH, and instructs the pilot to maintain airspeed that optimizes the aircraft range for the landing runway. The MP made a slight increase in power and decreased to 2° nose low to attain maximum glide capability in accordance with checklist procedures.

Step 2. LANDING SITE-SELECT

Step 3. THROTTLE-25%. The MP continued to make small throttle inputs required to maintain approach aircraft parameters (Tab V-1.8).

At 1854:18Z, 40 seconds later, the MP increased power from idle to 16%. Cylinder 1 EGT fell to 908° F and cylinder 2 EGT fell to 1,550° F. The forward cylinders' EGT indicated they were behaving normally. The next 3-minute period showed fluctuating EGT readings characterized by the reappearance of the EGT split, cycle-down normal EGTs for all cylinders, and then a subsequent reappearance of the EGT split between the aft and forward cylinders. The MP continued to make slight throttle adjustments to maintain a 2° glidepath and approach speed of 75 knots. The MP continued to adjust inputs to the MA for proper alignment with the runway and to maintain proper airspeed and glidepath (Tabs V-1.8, CC-3 thru CC-7).

At 1857:59Z, the aft cylinders (1 and 2) lost power, registering cold EGT readings of 571° F, the minimum temperature displayed in the GCS. The loss in power corresponded with pilot input of 100% throttle. Cylinders 3 and 4 were normal. The cold EGT readings indicate a lack of internal combustion within the aft cylinders due to a loss of ignition source. All other indications appeared normal: MAP 27.2 inHg; TAP 23%; engine speed 4,786 RPM; and propeller pitch decreased to 9.25°. The MP continued to make throttle adjustments to counteract the loss of 2 of the engine's 4 cylinders (Tabs V-1.8, CC-3 thru CC-7).

At 1858:23Z, the MP decreased power to 50%, followed 10 seconds later with an additional reduction to 35%. Initially, all 4 cylinder EGTs recovered to normal operating limits: MAP was 24.2 inHg; TAP was 15%; and engine speed read 3,590 RPM; with propeller pitch indicating 13.75°. Recovery of aft cylinders (1 and 2), indicate a fire, fail, and recovery ignition sequence within the MA Ignition Module (IM). Within a few seconds following the normal EGT indications, the re-emergence of EGT split developed again between the engine's aft (High) and forward (Normal) cylinders. The MA at this time was 1.2 miles from the runway (Tab CC-3 thru CC-7).

Before 1859:23Z, the MP reduced power to idle. Two seconds later at 1859:25Z the MP made a quick throttle input back to 38%. Corresponding to this increase of throttle from the MP, the MA's aft cylinders (1 and 2) indicated cold EGT temperatures (Tab CC-3 thru CC-7). The cold EGT in the aft cylinders (1 and 2) indicate these cylinders lacked combustion and did not regain normal operation/power prior to the MA impact with the ground. The loss of the engine's aft cylinders coincided with a throttle increase from the pilot. At this time, the MA's engine was only powered by 2 of the 4 cylinders (Tab V-1.8). The MP added throttle to compensate for the loss of power with the propeller feathering to try and maintain engine speed. The aircraft speed dropped from 74 knots to 65 knots with a noticeable loss of lift to the MA wings approaching 0.5 miles from the runway. Coincident with this loss of thrust, the MA experienced a wind shear and corresponding loss of approximately 9 knots of airspeed (Tabs V-1.8 thru V-1.9, V-1.11). At 1859:40Z, MA forward cylinders (3 and 4) registered cold EGT indications (Tab CC-3 thru CC-7). With the lack of combustion in these cylinders the MA experienced a complete engine failure. With no available engine power, MA airspeed decreased rapidly to 56 knots and encountered a stall condition to the wings (Tab V-1.8). The left wing stalled first beginning a left roll and a 15° nose low pitchover. The MP input forward stick pressure, attempting to regain flying airspeed but did not have the altitude available to recover. To save the MA, the MP attempted to reduce the descent rate with back stick pressure to flare the aircraft just prior to impact (Tabs V-1.8 thru V-1.9, V-2.5).

e. Impact

At 1900:16Z, the MA impacted the ground 92 meters short of runway 32 (Tab S-3). The MA engine restarted upon impact (Tabs R-9 thru R-13, R-15, R-18, R-20, S-3, V-1.9, V-2.5, classified video). Data-link with the MA was lost upon impact along with engine data logger indicators. The MA nose gear collapsed upon impact and the aircraft began sliding on the MTS and left wing. The MA spun counterclockwise approximately 500° before stopping, off the runway, pointing west (Tab S-3). The MP initiated engine shutdown first through normal procedures, then via the Ground Data Terminal (GDT) with no response from the MA. Emergency response crews shut down the engine and rendered the crash site safe (Tabs V-1.9, CC 3 thru CC-7). At 0700Z, the aircraft and its components were removed from the wreckage site to a hardened aircraft shelter for storage and analysis (Tab B-3).

f. Life Support Equipment, Egress and Survival

Not applicable to this mishap.

g. Search and Rescue (SAR)

Not applicable to this mishap.

h. Recovery of Remains

Not applicable to this mishap.

5. MAINTENANCE

a. Forms Documentation

A thorough review of the MA's maintenance documentation, recorded in the Air Force Technical Order (AFTO) Form 781 series, revealed no contributing discrepancies or issues (Tabs D-1 thru D-85, U-3). Minor documentation errors were found, but none of significance to this investigation.

None of the outstanding Time Compliance Technical Orders (TCTOs), which are instructions for accomplishing 'one-time' changes, modifications, inspections of equipment, and/or installation of new equipment, related to the accident (Tab D-16 thru D-18).

Historical records did not indicate any recurring maintenance problems.

b. Inspections

Inspections of the MA were driven by the requirements of Technical Order (T.O.) 1Q-1(M)B-6, *Aircraft Scheduled Inspection and Maintenance Requirements*, Change 1, published 05 March 2007, and modified by Interim Operational Supplement (IOS) T.O. 1Q-1(M)B-6IOS-1, dated 22 June 2007 (Tab U-4 thru U-9).

A Block 10 engine required the following periodic inspections (Tab U-8):

1. 25-hour Inspection	One-time inspection of a new engine
2. 60-hour Inspection	Accomplished every 60 engine operating hours
3. 360-hour Inspection	A major inspection requiring removal of the engine
4. 720-hour Inspection	A 360-hour inspection with additional requirements

On 28 June 2007, the MA's previous engine came due for a 360-hour inspection (Tabs D-41, U-10). During this inspection, the previous engine was replaced with the Mishap Engine (ME) Serial Number (S/N) E9530. The ME's last inspection was accomplished on 23 June 2007 (Tab D-50 thru D-64). After the ME installation, the MA received three routine inspections: a 60-hour engine inspection (14 July 2007); a 150-hour Airframe Phase Inspection (18 July 2007); and a 60-hour engine inspection (21 July 2007) (Tab U-11 thru U-13). The engine is limited to 1,080 total operating hours (Tab U-9). The total engine time of the ME prior to the start of the mishap sortie was 968 hours (Tabs D-3, D-14). No discrepancies were noted with regard to aircraft inspections.

c. Maintenance Procedures

During the 14 July 2007 60-hour inspection, the IM was replaced with the mishap IM S/N 3161 by civilian employees of Battlespace Flight Services, LLC (BFS) at Balad AB

(Tab U-3). The IM is limited to 1,080 total operating hours (Tab U-9). The total IM time of the mishap IM prior to the start of the mishap sortie was 103.3 hours (Tabs D-3, D-35). There are no indications that any maintenance procedure, practice, or performance contributed to this mishap.

On 28 July 2007, a Basic Postflight/Preflight (BPO/PR) was performed by a BFS employee with no discrepancies noted (Tab D-5). On 29 July 2007, the Exceptional Release was signed by a BFS employee with the aircraft deemed combat ready (Tab D-13).

d. Maintenance Personnel and Supervision

Predator maintenance at Balad AB is exclusively accomplished by BFS, headquartered in Las Vegas, Nevada. Review of BFS maintenance training records, confirmed all personnel involved with the MA were properly qualified (Tab U-14).

e. Fuel, Hydraulic and Oil Inspection Analysis

Post-accident analysis of bulk storage fuel at Balad AB was normal. Oil and hydraulic samples were not taken. Fuel and oil level readings transmitted during flight were normal (Tab J-3). There is no evidence that any fluids or fluid-servicing equipment contributed to this mishap.

f. Unscheduled Maintenance

Not applicable to this mishap.

6. AIRCRAFT AND AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Condition of Systems

Mishap analysis was conducted by using information downlinked to the GCS in the form of data log files (Tab CC-3 thru CC-7).

b. Analysis of Engine Failure

ENGINE DESIGN

The type of engine used in the MA, a Rotax model 914UL (also referred to in USAF technical data as I914F), is manufactured by BRP-Rotax GmbH & Co. of Austria. It is a four-cylinder, horizontally opposed, reciprocating power plant with a fuel injection/turbocharged induction system. The engine has a displacement of 1,211 cubic centimeters (73.9 cubic inches) and a 9.0:1 compression ratio (Tab BB-4).

Power output of the engine is controlled by the Primary and Secondary Control Modules (PCM/SCM) using a combination of computer logic, engine-mounted sensors and controls. When the pilot selects the desired engine power output through the throttle, the modules optimize power for given flight conditions through control of engine and propeller parameters. The control modules use several parameters to determine engine condition (Tab BB-4):

1. Outside ambient (static) air pressure
2. Throttle position (selected throttle setting by pilot)
3. Manifold pressure (or Manifold Air Pressure - MAP)
4. Engine speed (RPM)
5. Manifold charge (air) temperature
6. EGT temperatures
7. Oil, water temperature and pressure; alternator temperature

IGNITION MODULE DESIGN

Engine ignition is provided by a dual breakerless capacitive discharge system that provides ignition power for two spark plugs in each cylinder (Tab CC-9).

The components in the IM system form two independent capacitive discharge subsystems or Capacitive Discharge Ignition (CDIs). Each power box provides timed ignition power pulses to two ignition coils, and each coil provides spark to two cylinders. Each subsystem provides ignition power to the top spark plugs in two cylinders and the bottom spark plugs in two cylinders. The ignition system design is a redundant system that provides residual spark ignition in the event of a single failed CDI. Specifically, the failure of an individual CDI module only affects a single row of spark plugs, either all the tops or all the bottoms. If a single CDI module were to fail but all else was healthy then the engine would continue to run on the remaining row of active spark plugs at slightly lower RPMs (Tab CC-9).

IGNITION MODULE FAILURE

The MA's IM ceased operation in flight due to a dual failure of both CDIs internal to the engine's IM (Tabs EE-4, EE-12). The first CDI circuit failed due to an improperly manufactured wire-to-wire connection that was not soldered as required (Tabs EE-4, EE-12). The second CDI failed due to low reliability at high operating temperatures (Tabs CC-9, EE-4, EE-12). Due to throttle inputs and increased electrical loads in the CDI, the IM enclosure's design did not allow adequate heat dissipation of the CDI's internal circuitry (Tab EE-11). A coil drop test is part of the preflight engine checks performed by the launch crew and confirmed with ground maintenance personnel to valid normal operation (Tab BB-18). Prior to the MA's take-off, the launch crew and supporting maintenance personnel confirmed independent CDI operation (ground coil drop test) for a normal IM in accordance with checklist procedures (Tab BB-18).

IGNITION MODULE HEAT TEST

Post ME analysis performed by Detachment 3, 658th Aeronautical Systems Squadron confirmed that engine coolant, engine lubrication, engine alternators, and major engine mechanicals were all operating normally. The engine electrical system was operating normally and providing a good source of electrical power to the IM (Tab CC-3 thru CC-7). Inspection of the engine's internal magneto showed normal wear, and the condition of the magneto ring was acceptable. The resistance for coils #1 and #2 was evaluated. Coil #1 measured 3.9 ohms and was insensitive to the wire being wiggled. Coil #2 measured 4.0 ohms but was found very sensitive to wire movement and could easily be manipulated to form an open circuit (Tab CC-8).

The W452 magneto cable (S/N 3392) was removed for further evaluation. The overbraid was removed and a wiggle test was repeated to verify the location and behavior. The red wire for magneto 2 that goes to pin F on the connector failed at the location of the manufactured wire-to-wire connection. The W452 cable was x-rayed and the wire-to-wire connection on the red wire for coil #1 showed a good connection and the presence of solder. The red wire for coil #2 did not have solder at the connection (Tabs Z-3 thru Z-4, CC-8 thru CC-9).

This improperly manufactured wire-to-wire connection failed one of the two redundant CDI circuits (Tab CC-9). The effect of this single CDI failure reduced the redundant ignition system to one remaining CDI ignition source and a single point of failure (Tabs EE-4, EE-12). This, along with the IM enclosure's design, caused the heat increase in the single functioning CDI internal circuitry (Tabs EE-4, EE-12). Engine pre-flight checks direct a pilot to perform a coil drop test. This test confirms an independent operation of the IM's two CDI circuits. System design allows for a single CDI failure whereby the other operating CDI provides good ignition source to the engine. Preflight checks prior to the mishap flight were accomplished by the launch crew and showed both CDI circuits operated properly during ground operations (Tab EE-12). The redundant design of the IM ensures ignition with the failure of a single CDI. There is no indication to the aircrew (through a software-generated warning message) of a single CDI failure. The faulty wire-to-wire connection failed after the ground check (Tab EE-12). Results from the engine data loggers show that ignition source to the engines and the random fire, fail, and recovery indications are consistent with a broken wire or bad connection. The single CDI failure of the faulty wire-to-wire connection, by itself, would not cause a lack of consistent ignition source to the engine from the dual redundant IM or explain the EGT split between the aircraft engine cylinders (Tabs CC-3 thru CC-7, CC-9) (Tab EE-11).

Further post crash analysis of the UPA13695-1 ignition assembly (S/N 3161), the MA IM, was tested at a simulated engine speed of 5,000 RPM in an environmental chamber. Test results confirm intermittent loss and return of continuity when the MA's IM was subjected to tests of increasing temperatures and durations. The IM produced random and intermittent spark to the aircraft cylinders when tested against increasing operating temperatures. At 120° C, aft cylinders (1 and 2) received random and intermittent spark. At 128° C, aft cylinders (1 and 2) lost spark. At 130.1° C, forward cylinders (3 and 4) became spotty/intermittent. Ignition to all engine cylinders (upper spark plugs) was lost when temperatures rose to 142.6° C (Tab CC-8).

This test confirmed that an IM with only a single operating CDI eventually fails to produce properly sequenced cylinder ignition to engine spark plugs when stressed under increasing electrical load/internal heat buildup. The improperly manufactured wire-to-wire connection did not allow electrical power to the CDI powering the MA's lower spark plugs (Tabs EE-12). The remaining CDI that provides power to the upper spark plugs began to fail when the internal operating temperature began to rise (Tab EE-11 thru EE-12). The rise in internal temperatures was due to increased electrical loads to the single operating CDI at higher power settings (throttle inputs) and inadequate enclosure design (Tab EE-11). Test results show ignition source to the aft cylinders (1 and 2) failed with increasing temperatures causing a total loss of power to these cylinders. Forward cylinders (3 and 4) ignition failed only 12.6° C later with a corresponding total loss of power in these cylinders. Without the redundant source of ignition spark, and/or an IM enclosure able to dissipate internal heat loads, ignition source is cut off to the aircraft engine resulting in a complete engine failure (Tab CC-3 thru CC-8).

ENGINE DATA LOG GRAPHS

The test results are consistent with actual data taken from the MA data log graphs. During the last eleven minutes of flight the MA experienced an erratic ignition source to aircraft cylinders followed shortly by a complete ignition failure as IM internal temperatures rose. The subsequent loss and return of ignition source is indicated by the EGT split displayed in the MA's engine data loggers and typical of an IM failure. IM failure is usually not immediate. First, the IM spark becomes weak and random producing erratic engine due to cylinder mis-fires. The mis-firing cylinders result in an overall lower power output of the engine. Increased throttle inputs are required to counter the loss of power. Increased throttle inputs increase electrical loads and create higher internal CDI temperature. Second, when the temperature exceeds the internal circuit capacity it begins a series of fire, fail and recovery cycles with time to cool. With long-term exposure to high temperatures the IM fails completely resulting in no ignition source and engine failure. Indications of an overheating IM manifest themselves in split EGT indications displayed through the GCS VITs (Tabs CC-3 thru CC-9, Z-3 thru Z-4).

EGT thermocouples are positioned in the exhaust system about four inches from the exhaust port that measure the temperature of the exhaust gas released from the cylinder heads after combustion (Tab BB-7 thru BB-8). Normal ranges for EGT are 1,000-1,700° F. (Tab BB-15 thru BB-16) Normal readings are indicative of good cylinder combustion and available spark. Low EGT readings can indicate negative combustion (or lack of ignition spark) and incomplete combustion due to a weak/random ignition source. High EGT readings can be indicative of either hot combustion and/or negative combustion. High EGT indications associated with hot combustion are usually accompanied with higher Cylinder Head Temperatures (CHT). Data loggers show that at no time during the final eleven minutes of flight did CHTs appear abnormal (Tab CC-3 thru CC-7). High EGT indications associated with negative combustion (lack of spark) are usually accompanied by an EGT split when the unburned fuel is ignited in the exhaust pipe, rather than in the cylinder.

Prior to 1849:39Z, all 4 EGT readings moved up or down together at roughly the same time and temperature. From 1849:39Z to MA impact at 1900:16Z engine EGT readings split between the aft and forward cylinders between 200 and 400° F. This difference in EGT readings was not related to the aircraft fuel supply or available electrical power. All other engine systems (MAP, oil, and coolant) tracked correctly with pilot inputs. The momentary recovery of normal EGT readings at 1851:29Z was typical of an overheated IM failure where the spark becomes weak and random. The weak ignition failed at high power loads and recovered at light power loads with time to cool. This is shown in the engine data log graphs at times 1851:29Z and 1858:33Z where cylinder EGTs recovered to normal levels following a short recovery period of a few seconds and an increase in throttle. The weak ignition spark to the aft cylinders dropped engine output requiring the pilot to compensate with further increases in throttle input. The higher power settings increased the electrical load within the single-operating CDI and caused internal operating temperature to increase. Improper IM enclosure design did not allow proper cooling for the CDI to continue normal operations. This corresponds to post ME analysis when the MA's IM became unreliable when tested against increasing operating temperatures (Tab CC-1 thru CC-9).

At both 1857:59Z and 1859:23Z EGT readings for the aft cylinders registered cold at 571° F. This indication is critical as it is the lowest value that can be displayed by the GCS. The low EGT readings indicated a loss of ignition and subsequent power to the aft cylinders. At both of these times, the cold EGT indications of both cylinders followed an increase in fuel from increased throttle input. Given that in periods prior to these times the aft cylinders (1 and 2) were not receiving adequate spark from the IM, and therefore no combustion, the exhaust pipe temperature cooled over time and did not ignite the unburned fuel. Additionally, the increase in cool unburned fuel from the increased throttle inputs contacted the exhaust pipe walls and decreased its temperature below that required to ignite the fuel within the exhaust pipe itself (Tab CC-3 thru CC-7).

Pilot throttle inputs were consistent in response to the loss of power from the aft engine cylinders. Random and weak ignition first manifested itself in the aft cylinders beginning at 1849:39Z, indicated by the EGT split amongst aircraft cylinders. The EGT split remained mostly constant for the last 11 minutes of flight signifying lack of a consistent ignition source. System failure was not immediate. At first the magneto began to fire randomly on coil #1 that controlled the aft cylinders (1 and 2) while the magneto appeared to operate normally on the coil #2 that operated the forward cylinders (3 and 4). When the MP began to increase throttle inputs to compensate for the loss of engine power the electrical load and internal heat began to rise in both coils within IM. As the temperature within the IM continued to rise, the system ignition began a series of fire, fail, and recover signals until 1859:23Z when coil #1 for the aft cylinders failed completely and did not recover. At 1859:40Z, (17 seconds later), the forward cylinders (3 and 4) ignition failed. Coil #2 failed due to increased electrical load and internal heat buildup of the engine's only remaining operative coil. Neither spark plug coil regained electrical continuity prior to the MA impact at 1900:16Z (Tabs CC-3 thru CC-7, CC-9).

At impact, the MA stopped transmitting data logger information to the GCS. Following impact, some or all, of the engine's cylinders restarted (Tabs R-9 thru R-13, R-15, R-18, R-20, S-3, V-1.9, V-2.5, classified video).

Engine analysis points at dual failure of the redundant IM resulting in an engine out condition. When the wire-to-wire connection was broken, only four of the engine's eight spark plugs received an ignition charge. The remaining operative CDI began failing when internal operating temperatures rose due to higher electrical loading with inadequate heat dissipation of the IM. The failure of this remaining CDI was not immediate but progressed over time during the final 11 minutes of flight when complete failure occurring seconds prior to impact.

7. WEATHER

a. Forecast Weather

Forecast weather data masked for security classification.

b. Observed Weather

The observed weather in the mishap area had unrestricted visibility, few clouds at 15,000 feet, and wind direction at 340° at four knots. Winds at 4,000 feet MSL were 310° at 15-20 knots. The observed meteorological data suggests there was a radiational inversion during the MA final approach. Comparing the aircraft data (17 knots) with surface observations (4 knots), there was a loss of approximately 9 knots of airspeed on final approach as the MA descended through 400 feet Above Ground Level (AGL). This translates to a 15% reduction of flying airspeed, putting the aircraft within 5 knots of its 56 knot stall speed. These inversions are not typically forecasted for and are considered common nocturnal features often occurring many days in a row (Tab K-11). Aircraft with lower approach speeds are more susceptible to this phenomenon (Tabs F-3 thru F-4, V-1.4, V-1.9, V-1.11).

c. Space Environment

There were no interruptions with the C-band data-link. The space environment was not a factor.

d. Conclusion

Weather did not significantly contribute to the mishap (Tabs V-1.4, V-1.9, V-1.11, classified tapes).

8. CREW QUALIFICATIONS

A thorough review of the MC's flight records revealed no evidence that crew qualifications contributed to the accident.

a. Mishap Pilot

The MP is a senior pilot and has extensive flying experience in his six years of aviation service, including over 1700 hours in the T-38, F-16C, and MQ-1 aircraft (Tab G-6 thru G-7). At the time of the mishap, the MP was a qualified Predator Instructor Pilot. He completed initial MQ-1 Predator Pilot qualification on 06 October 2005, was certified combat mission ready and was current in all flying events required for the mission (Tab G-16). His total flying time in the MQ-1 Predator was 742 hours and he was considered experienced (Tabs G-6, G-16). The MP was certified as a Launch and Recovery Instructor Pilot on 04 April 2007 (Tab G-16). A summary of the MP's recent flight time is depicted as shown (Tab G-3).

	HOURS	SORTIES
30 days	61.6	71
60 days	103.2	125
90 days	108.8	129

b. Mishap Sensor Operator

The MSO was a qualified MQ-1 Predator Sensor Operator and was certified combat mission ready and current in all flying events required for the mission (Tab G-18). He was an experienced MSO with over 1259 hours flying the MQ-1 Predator (Tabs G-8, G-18). A summary of the MSO's recent flight time is depicted as shown (Tab G-8).

	HOURS	SORTIES
30 days	46.4	61
60 days	74.9	101
90 days	128.8	120

9. MEDICAL

a. Qualifications

The MP and the MSO were medically qualified to perform Predator crew duties at the time of the mishap (Tab T-3 thru T-4).

b. Health

There is no evidence to suggest the health of the MP or MSO was a factor in this mishap.

c. Toxicology

Toxicology testing of the MP and MSO following the mishap indicated normal levels of carbon monoxide and no traces of ethanol, amphetamine, barbiturates, benzodiazepines, cannabinoids, cocaine, opiates or phencyclidine (Tab T-5 thru T-7).

d. Lifestyle

There is no evidence to suggest the lifestyle of the MP or MSO was a factor in this mishap.

e. Crew Rest and Crew Duty

Based on pilot testimony, crew rest was within regulation and not an issue to this accident (Tabs V-1.2, V-2.2).

10. OPERATIONS AND SUPERVISION

a. Operations

At the time of the mishap, the operations tempo for the 46 ERS was high. The squadron was responsible for executing Predator reconnaissance in support of Operation IRAQI FREEDOM on a 24-hour per day, 7-day per week basis. The impact occurred 20.4 hours after takeoff (Tab K-6). An Operational Risk Management (ORM) evaluation was conducted prior to the mission and the scores for both the MP and MSO assessed as low (Tab T-8). Operations tempo was not a factor in this mishap (Tabs V-1.2 thru V-1.4, V-1.9, V-2.2 thru V-2.3).

b. Supervision

Supervision was not a factor in this mishap (Tab V-1.9).

11. HUMAN FACTORS

Human Factors on the part of the aircrew or the maintainers was not a factor to this mishap (Tabs V-1.2 thru V-1.4, V-2.2 thru V-2.3).

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Primary Operations Directives and Publications

1. Air Force Instruction (AFI) 11-2MQ-1, Volume 1, *MQ-1 Crew Training*, 04 May 2007.
2. AFI 11-2MQ-1, Volume 2, *MQ/RQ-1 Crew Evaluation Criteria*, 02 August 2005.

3. AFI 11-2RQ-1, Volume 3, *RQ-1 Operations Procedures*, 28 February 2002.
4. AFI 11-202, Volume 1, *Aircrew Training*, 17 May 2007.
5. AFI 11-202 Volume 2, *Aircrew Standardization/Evaluation Program*, 19 September 2007.
6. AFI 11-202, Volume 3, *General Flight Rules*, 05 April 2006.
7. AFI 11-401, *Aviation Management*, 07 March 2007.
8. AFI 11-418, *Operations Supervision*, 21 October 2005.
9. T.O. 1Q-1(M)B-1, 01 November 2003, USAF Series MQ-1B and RQ-1B Systems Flight Manual, with Change 8, 22 January 2007.
10. T.O. 1Q-1(M)B-1CL-1, 01 November 2003, USAF Series MQ-1B and RQ-1B Systems Flight Checklist, with Change 9, 30 March 2007.

b. Maintenance Directives and Publications

1. T.O. 1Q-1(M)B-6, Aircraft Scheduled Inspection and Maintenance Requirements, MQ-1B Remotely Piloted Aircraft, 01 January 2007.
2. T.O. 1Q-1(M)B-6WC-1, Inspection Workcards for Pre-flight, Thru-flight, Basic Postflight and Combined Basic Post/Preflight Inspection Requirements, MQ-1B Remotely Piloted Aircraft, 15 January 2007.
3. T.O. 1Q-1(M)B-6WC-2, Aircraft Periodic Inspections and Maintenance Requirements, MQ-1B Remotely Piloted Aircraft, 17 January 2007.

NOTICE: The AFIs listed above are available digitally on the AF Departmental Publishing Office internet site at: **http://www.e-publishing.af.mil.**

c. Known or Suspected Deviations from Directives or Publications

There are no known or suspected deviations from directives or publications by crew members or others involved in the mishap mission.

13. NEWS MEDIA INVOLVEMENT

United States Central Command Air Forces Public Affairs released a news release on 30 July 2007 stating when and where the MA crashed and that a board will be convened to investigate the incident. One article was released by the Air Force Print News Today service on 01 August 2007 and one article was released by Space Daily on 07 August 2007. Both articles highlighted the fact that this was the first of two Predator crashes at Balad AB in two days. (Tab DD-3 thru DD-5).

30 January 2008

TODD J. FLESCH, Lt Col, USAF
President, Accident Investigation Board